International Joint Commission
Commission mixte internationale

March 7, 1989

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Secretary of State for External Affairs
Lester B. Pearson Building
125 Sussex Drive
Ottawa, Ontario
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The Honourable James A. Baker, III
Secretary of State
Department of State
Washington, D.C. 20520

Dear Sirs:

With this letter we transmit to Governments the Fourth Biennial Report of the International Joint Commission pursuant to its responsibilities under the 1978 Great Lakes Water Quality Board Agreement, as amended. The report is also being sent to the Governors of the Great Lakes States and to the Premiers of the Provinces of Ontario and Quebec.

The Commission notes that considerable progress has been made in many areas related to improving the water quality of the Great Lakes, but that much remains to be done with regard to toxic chemical contamination. The Commission is encouraged by the commitments made by Governments in the Protocol Amending the 1978 Agreement and the increased accountability which will result from the reporting of progress under the various annexes. The Commission will continue to report to Governments on progress toward achievement of the objectives of the Agreement and will respond to the specific tasks assigned to it under the Agreement.

The Commission hopes that the views expressed in this report will assist the Governments of Canada and the United States, as well as the state and provincial governments, to advance further the fulfilment of their commitment to the restoration and enhancement of the Great Lakes ecosystem.

P. - André Bissonnette
Chairman

Robert C. McEwen
Chairman

International Joint Commission
United States and Canada

FOURTH BIENNIAL REPORT UNDER THE GREAT LAKES WATER QUALITY AGREEMENT OF 1978 TO THE GOVERNMENTS OF THE UNITED STATES AND CANADA AND THE STATE AND PROVINCIAL GOVERNMENTS OF THE GREAT LAKES BASIN

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INTRODUCTION

The 1978 Great Lakes Water Quality Agreement requires the International Joint Commission to make a full report to the Governments of the United States and Canada, and to the state and provincial governments, no less frequently than biennially. The Agreement calls for the Commission's report to include an assessment of the programs and measures undertaken pursuant to the Agreement. This is the Commission's Fourth Biennial Report under the Agreement. It focuses not only on progress made under the Agreement and the Commission's assessment of the state of the lakes, but also examines the extent to which the Parties have achieved the purpose of the Agreement: to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem.

As reported in previous biennial reports, the Parties and state and provincial governments have made considerable progress in many areas related to improving the water quality of the Great Lakes. Governments have implemented programs to alleviate much of the highly visible pollution from municipal and industrial sources, and to prevent pollution from shipping sources, although much remains to be done in implementing these programs. The focus has shifted in recent years to controlling inputs of toxic substances to the lakes, although efforts to control conventional pollutants and phosphorus discharges must also continue. Some progress has been made in identifying sources and quantifying inputs of toxic contaminants to the waters; despite this, the goal of "virtual elimination" of inputs of persistent toxic substances to the Great Lakes remains an unmet challenge.

The Commission's Third Biennial Report, in addition to assessing progress under the Agreement, provided advice to assist Governments in their review of the operation and effectiveness of the Agreement. The Commission recommended that the 1978 Agreement should remain in force and not be subject to comprehensive renegotiation. In recommending this approach, the Commission concluded that new thrusts and issues, as well as intensified efforts on existing issues, could be accommodated within the language of the existing Agreement. The Commission recommended that "the Parties, in consultation with the Great Lakes jurisdictions, clarify the language and intent of some of the provisions, and demonstrate through increased effort the will to achieve the goals to which they had committed themselves."

In November 1987, following consultations with government agencies at the federal, provincial and state levels, and with the public, the Governments of Canada and the United States signed the 1987 Protocol Amending the 1978 Great Lakes Water Quality Agreement. The Commission is gratified to note that the Protocol substantially reflects the foregoing general recommendation, as well as many of the

specific recommendations in the Third Biennial Report. The signing took place at the Commission's Biennial Meeting on Great Lakes Water Quality in Toledo, Ohio.

The revised Agreement contains specific commitments to strengthen efforts which address the continuing contamination of the Great Lakes by dealing more directly with all sources of contamination. In addition, it requires the Parties to meet twice each year to coordinate efforts and evaluate progress, and to report biennially on such activities. This process should help the Commission in its review function.

New annexes to the Agreement focus attention on assessing the contribution of nonpoint sources, contaminated sediments, airborne toxic substances and contaminated groundwater to pollution of the lakes, and on developing programs and control measures to alleviate the detrimental effects of these sources. A supplement to Annex 1 outlines commitments with respect to specific objectives, lake ecosystem objectives and the categorization of toxic substances believed to be present or having the potential to be discharged into the system. A new Annex 2 for Remedial Action Plans (RAPs), Point Source Impact Zones and Lakewide Management Plans replaces a previous annex which dealt with the identification and designation of limited use zones. Annex 17 outlines research and development needs to support the achievement of the goals of the Agreement.

Following the signing of the Protocol, the Commission reviewed its activities and adopted a policy statement on its approach to the revised Agreement. This statement was sent to Governments in October 1988 and is included as Appendix A.

In this report, the Commission assesses progress made under the Agreement, and identifies and discusses several subjects which it wishes to bring to the attention of the Parties. The Commission's review of the state of the lakes indicates a need for improved data management and analysis, increased efforts in biological monitoring, improved quality control in monitoring and surveillance for conventional and toxic pollutants, and upgraded monitoring for radioactivity. The report also provides an opportunity for the Commission to suggest concepts it believes are relevant to the development of atmospheric monitoring networks.

This report is organized along four broad issue areas:

I Progress with respect to restoring and maintaining the integrity of the waters of the Great Lakes Basin Ecosystem: "The Condition of the Great Lakes Ecosystem";

II Progress with respect to the Parties' efforts to develop programs, practices and technologies to eliminate or reduce, to the maximum extent practicable, the discharge of pollutants into the Great Lakes system: "Institutional Arrangements and Programs for Ensuring Progress Under the Agreement";

III Considerations with respect to science and information needs to gain a better understanding of the Great Lakes Basin Ecosystem: "Science and Agreement Programs";

IV Recognition that the adoption of an ecosystem approach requires anticipatory and adaptive attitudes in addition to remedial measures: "Great Lakes Futures."

I. THE CONDITION OF THE GREAT LAKES BASIN ECOSYSTEM

Perspectives on the State of the System

In signing the 1978 Great Lakes Water Quality Agreement, the Governments of Canada and the United States agreed to a far-reaching statement of purpose with respect to the waters of the Great Lakes system. The Parties' commitment to "restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem" reinforced the growing recognition of the need for an ecosystem perspective when addressing the factors that threaten the quality and integrity of the waters of the Great Lakes system.

The general and specific objectives outlined in the Agreement provide one set of criteria for measuring progress, but they provide little guidance in assessing the integrity of the Great Lakes system. The International Joint Commission and the Great Lakes Fishery Commission cosponsored a workshop on "Ecosystem Integrity in the Context of Surprise" in June 1988 to develop a better understanding of the concept of integrity as it applies to the Great Lakes ecosystem. The workshop provided a foundation for further discussion and clarification of this concept.

While an assessment of the lakes' condition can be partially based on quantitative empirical data, many subjective considerations also enter into the assessment process. One of the most important of these considerations is the extent to which a specific indicator or measure provides an assessment of the integrity of the Great Lakes system. The Commission has long concluded that single indicators, such as general and specific objectives, do not by themselves provide an effective assessment. Several different types of indicators and data and information from a wider range of systems and situations needs to be holistically analyzed in order to develop a comprehensive assessment of the state of the lakes.

Annex 2, paragraph 1(c) of the amended Agreement lists several conditions that constitute impairments of beneficial uses as a result of changes in the chemical, physical or biological integrity of the Great Lakes system. Examples of use impairments include restrictions on fish and wildlife consumption, restrictions on drinking water consumption, beach closings, degradation of aesthetics and loss of important habitats. The Commission views the introduction of these conditions as the basis for developing beneficial use objectives and more broadly based criteria for assessing the integrity of the ecosystem. As such, they can begin to give practical meaning to the concept of ecosystem integrity. By relating objectives to specific uses, a broader public understanding may be facilitated as to how the Agreement relates to individuals and their environment.

Past assessments on the condition of the Great Lakes have been based on limited information for selected components of the ecosystem. While such analyses may be adequate for specific issues with visible signs of impairment, such as with eutrophication — when floating masses of nuisance algae are a visible sign of the problem, and their reduction or disappearance following the implementation of nutrient control programs is an equally visible sign of improvement — the problems of toxic contaminants are considerably different. The signs tend to be more subtle, the effects and solutions more obscure. Ecosystem approaches then become more important in order to integrate information from several divergent sources.

The Great Lakes Water Quality Board, in its 1987 report to the Commission, included a major section on the state of the lakes and indicators of ecosystem health. Most of the chapter's information was derived from government monitoring programs modeled, in part, after the Great Lakes International Surveillance Plan (GLISP), developed and revised under the auspices of the Water Quality Board. GLISP provides a framework within which appropriate data can be collected and organized for assessing the state of the lakes and connecting channels. The latest revision of GLISP goes beyond traditional water chemistry parameters to encompass a holistic ecosystem approach.

While considerable progress has been made to resolve some water quality problems, as outlined below, the Great Lakes ecosystem's present condition does not meet the Agreement's General and Specific Objectives in many ways. Surveillance data have demonstrated that objectives are exceeded in the vicinity of many industrial and municipal outfalls, and as a result of pollution inputs from sources such as contaminated sediments, atmospheric deposition, urban and rural land runoff, contaminated groundwater inflows, and spills and accidents.

All connecting channels in the Great Lakes system have been designated Areas of Concern. While local sources of pollution are major contributing factors, these waterways integrate the state of the overall system. Thus, they reflect the combinations of stresses in upstream sections of the system and contribute to the ecosystem integrity of downstream receiving waters.

Fish consumption advisories provide another example of the spatial extent of the problem. Data presented by the Water Quality Board clearly show that toxic substances are being accumulated by fish in many areas of the Great Lakes system. These issues point to the need for holistic and ecosystemic approaches to analyzing the integrity of the Great Lakes system.

Eutrophication

The eutrophication issue, which was the focus of the 1972 Agreement, is a remarkable success story. The problem had highly visible symptoms, such as nuisance algae blooms and extensive fish kills. To a large extent, the blame rested on excessive nutrient inputs, primarily phosphorus, to the system. The problem was amenable to technological solutions as most of the phosphorus came from controllable point sources (i.e. municipal sewage treatment plants). Construction of new municipal wastewater treatment facilities and improvements in existing facilities, as well as reduced phosphorus content of laundry detergents, resulted in lower phosphorus loads and lower ambient concentrations throughout the system. Nuisance algal blooms continue to decline in number, frequency, duration or persistence, and intensity. Taste and odour problems associated with nuisance algae have become extremely rare.

In its 1987 report to the Commission, the Water Quality Board reported that, "Based on traditional trophic indices, it can be concluded that the phosphorus control program has been successful in maintaining the oligotrophic status of Lakes Superior and Huron and has helped to restore Lakes Michigan, Erie and Ontario to an oligo-mesotrophic state." This is a major accomplishment. Not only has the degradation been reduced, but in some instances, it has been reversed. The success of this effort is due, in no small part, to the public constituency that supported and encouraged action.

Another positive sign is the composition of plankton communities, where changes to more desirable species are occurring. Some pollution-sensitive forms have returned, and fewer communities are dominated by nutrient tolerant species. Diatoms and certain green algae, a more desirable food supply for invertebrates and valued fishes, are being found more frequently in phytoplankton communities. As a result, several larger invertebrate species, notably *Daphnia pulicharia*, appear in zooplankton communities where only smaller zooplankton forms previously were found.

One indicator of ecosystem health that has not responded as expected is the oxygen deficit in the central basin of Lake Erie. The Agreement goal "to restore year-round aerobic conditions in the bottom waters of the central basin of Lake Erie" has yet to be realized. The Water Quality Board and the Commission encourage continued efforts in this direction.

Another area where efforts may be needed is in addressing the general increase in nitrate and nitrite concentrations in the waters of the Great Lakes system, a trend the Water Quality Board confirmed in its 1987 report. Elevated nitrogen concentrations may relate to additional

direct inputs, or they could be more a result of an increased surplus that exists because the reduced input of phosphorus has limited the capacity of algae to utilize nitrogen. It is also not clear whether these increased nitrogen concentrations should be a concern from the eutrophication aspect, or of benefit to desirable algal species that are unable to utilize atmospheric nitrogen.

The Great Lakes Science Advisory Board has indicated that levels of nitrogen in the waters of the Great Lakes system are unlikely to pose a problem for aquatic organism health, but recommended that levels of nitrate + nitrite be monitored and encouraged further studies of the nitrogen cycle. Because increasing levels of nitrate + nitrite are potentially toxic to humans and livestock, the Commission supports the Water Quality Board's recommendation that the cause of excessive levels of nitrate + nitrite should be identified and that research should be undertaken to determine the possible short and long-term impacts of these increasing levels. Because of the uncertainty that exists, the Commission recommends that:

1. *the Parties and jurisdictions undertake studies to determine the levels of nitrogen compounds which endanger the health of humans and livestock, and consider programs to address this emerging problem if the current trend of increasing levels of nitrogen compounds continues.*

Toxic Substances

There are enormous detection and analytical problems associated with the study and control of toxic substances. Concentrations of substances that are now known to cause problems are often so low in open waters that they are below limits of analytical detection. Many of these substances bioaccumulate in aquatic organisms where they act singly or in synergistic or additive ways. It is extremely difficult to establish cause-effect relationships when the effects often cannot be measured, especially when they are due to the additive or synergistic impacts of chemical mixtures.

The information base available to assess the state and effects of contaminants in the ecosystem is more diverse and more fragmented than that available for assessing eutrophication. Nevertheless, a great deal of relevant information has been accumulated. We now know that predators at the top of the food chain, including humans, are particularly vulnerable to effects because of the biomagnification of persistent toxic substances through the food chain. Hence, predator species have been recognized as excellent indicators of the state of the ecosystem, and information on some species is now sufficient to clearly link chemical contaminants to a variety of biological responses. These responses have been documented at levels of biological organization ranging from subcellular to entire populations. Fish-eating birds, especially colonial

waterbirds such as cormorants and ducks, have proven especially useful as overall indicators of ecosystem health.

Perhaps the single most encouraging information on the state of the Great Lakes ecosystem is that many colonial waterbird populations that formerly had poor reproductive success are producing more offspring. Populations that were once declining have increased substantially, and reproductive problems in fish-eating birds are generally confined to specific sites. Similarly, increased bald eagle nesting sites are being reported in the basin. While it is still absent from some of its former haunts, bald eagles have expanded into new areas where earlier populations once nested.

Concentrations of selected contaminants have been tracked in a variety of species, including young-of-the-year spottail shiners, rainbow smelt, lake trout and herring gulls. Between 1969 and 1972, legislation was enacted in one or both countries to restrict or ban the use of dieldrin, heptachlor, DDT, PCBs, mercury and mirex. For the most part, residues of these controlled chemicals decreased in the 1970s in species selected to monitor the response of the system. In recent years however, several samples indicate a leveling off or even a reversal of these earlier trends. Dieldrin, for reasons that are not clearly understood, generally has not declined significantly in monitored species. Fortunately dieldrin concentrations in lake trout are, with the exception of Lake Michigan, below the current objective of 0.3 mg/kg in the edible portion.

While the biomagnification of contaminants through the food chain has been well documented, the effects of these body burdens on organisms have been harder to document. It is known that contaminant burdens can lead to a variety of deformities in fish-eating birds, and there is increasing evidence that contaminant burdens can also lead to tumours and fin asymmetry in fish. One finding reported by the Water Quality Board in its 1987 report to the Commission was that the levels of PCBs in fish, known to be consumed by mink, were at levels known to be associated with reproductive failure in mink. Additional scientific studies are currently being undertaken.

Recent research on the role of sediments as sinks and sources of contaminants in the Great Lakes system draws attention to a number of information deficiencies. While we know that sediments tend to accumulate high concentrations of many contaminants, more information is required on the horizontal and vertical distribution of contaminants in the bottom sediments of the Great Lakes system. Similarly, there seems to be little recent information on the distribution and abundance of benthic (bottom dwelling) communities in the Great Lakes system. These organisms have long been recognized as excellent indicators of the health of aquatic systems. Their response to, and effects from, contaminated sediments are likely to be important factors in assessing

site specific problems of contaminated sediments.

The Commission notes a leveling off of some toxic residues in various environmental sectors of the Great Lakes. Although data are not definitive enough to confirm or refute a true leveling off, the observations suggest the need for studies to determine whether existing control systems have reached technical limits, and therefore no further decline in residues is possible under existing management and control strategies, or whether some controlled chemicals are no longer causing problems. In such cases, the need to improve the ecological health of the Great Lakes depends on monitoring and controlling other chemicals. Research is also needed to determine whether a species' cumulative exposure to some toxicants has led to undesirable genetic or physiological change and, whether survival of important Great Lakes species is dependent on physiologically damaged but reproductively successful adaptations.

Introduction of Non-Native Species

The integrity of the Great Lakes ecosystem requires the maintenance of a balanced yet dynamic natural system. Introduced species can seriously affect the balance and distribution of native species by altering the structure and developmental patterns of their biological communities. Introduced species often lack natural predators and, given an adequate food supply and appropriate life support systems in the area of introduction, they can become a serious threat if they outcompete or destroy valuable native species.

Concerns about introduced species, notably the sea lamprey and smelt, preceded the signing of the 1972 Agreement. Since then, and especially in recent years, the number of intentionally or unintentionally introduced species in the Great Lakes has increased significantly. Among the more widely known species introduced into the Great Lakes are the alewife, the coho salmon, the Asiatic clam, the zebra mussel, the crustacean *Bythotrephes cederstroemi*, and the river ruffe. Fisheries authorities introduced the coho salmon to provide a sports fishery resource while providing some predator control on the alewife. The Asiatic clam, originally introduced into rivers in the western United States, has extended its range eastward to the Great Lakes. The clam attaches itself to intake screens and pipes of water treatment plants and other industrial systems and affects flows, fouls surfaces, and causes equipment problems. The zebra mussel behaves similarly and is quickly becoming a major nuisance. *Bythotrephes cederstroemi* occurs in the zooplankton communities and feeds on smaller organisms important in controlling algae. How it will affect Great Lakes biological communities is unknown at this time. The river ruffe consumes the eggs and larval forms of fishes and thus could threaten the lake trout. Fisheries authorities have expressed concern because the species is not considered a de-

sirable sport or food fish. In European lakes where it has become established, it has rapidly become a dominant fish species.

The zebra mussel, *Bythotrephes cederstroemi* and river ruffe appear to have been introduced into the Great Lakes from ballast water discharges of arriving ships. In August 1988, the Commission wrote to Governments indicating its concern about the problems of non-native species introduced into the Great Lakes ecosystem through the discharge of vessel ballast water and recommended that Governments examine the matter with a view to preventing future introductions of exotic species to the lakes from this source. The Commission encourages the Coast Guards to address the problem in accordance with Annex 6 of the Agreement, and further recommends that:

2. *the Parties take steps to prevent the further introduction, particularly the unplanned introduction, of exotic life forms into the Great Lakes ecosystem.*

Coastal Wetlands

Coastal wetlands perform several critical ecological functions: filtering and decomposing wastes; acting as nursery grounds for immature stages of fishes and invertebrates; providing resting and breeding places for birds and mammals; and acting as buffer zones against a variety of environmental fluctuations in geophysical processes (notably storms, erosion and subsidence). Loss of wetlands thus means a loss of these valuable ecological functions, to the detriment of the health of the Great Lakes system.

In the last century the Great Lakes system is estimated to have lost nearly 50 percent of its original wetland area, and continuing pressures for development are likely to lead to increased losses. Through Annex 13(3) of the Agreement, the Parties commit themselves to identify, preserve, and where necessary, rehabilitate significant wetland areas that are threatened by urban and agricultural development and waste disposal activities. The Commission is concerned about the loss of coastal wetlands in the Great Lakes region and welcomes this initiative. Thus, the Commission recommends that:

3. *the Parties and jurisdictions increase efforts to rehabilitate, protect and preserve Great Lakes coastal wetlands and to strengthen and initiate programs which reverse wetland loss.*

II. INSTITUTIONAL ARRANGEMENTS AND PROGRAMS FOR ENSURING PROGRESS UNDER THE AGREEMENT

The Parties and jurisdictions, individually and collectively, have undertaken a number of recent initiatives in support of their commitment to achieving the goals and objectives of the Agreement. These initiatives include new legislation, bilateral and multilateral agreements, and domestic programs to characterize and restrict pollutant discharges. A number of these initiatives are highlighted in this section.

The 1987 Protocol Amending the 1978 Great Lakes Water Quality Agreement

The signing of the 1987 Protocol by the Parties is a major step forward in the cooperative effort to restore and enhance the quality of the Great Lakes. Through the Protocol, the Parties reaffirmed their commitment to achieving the goals of the 1978 Agreement, recognized the need for strengthened efforts to address persistent toxic substances and agreed to improve the management processes for achieving the Agreement's objectives. The Parties committed themselves to increase efforts that will address all sources of pollutants to the lakes, including nonpoint sources, sediments, airborne toxic substances and groundwater. Each new annex includes a commitment by the Parties to report progress biennially to the Commission, commencing with their first report by the end of December 1988. The Commission will use these reports as one source of information to assess progress under the Agreement.

Annex 2 of the Agreement, which addresses Areas of Concern, Remedial Action Plans, Critical Pollutants, Lakewide Management Plans and Point Source Impact Zones, should become a focus for activity. This annex will likely have a bearing on how progress under the Agreement is evaluated. The annex on research and development highlights the importance of these aspects and focuses attention on priority research needed to support the Agreement's goals.

While the Commission notes the Parties' renewed commitments to the Agreement, the true measure of progress under the Agreement is the implementation of the various clauses and their resulting impact on the environmental quality of the lakes. In its Third Biennial Report, the Commission stressed the need for the development and implementation of a Binational Toxics Management Strategy to control and reduce toxic substances in the Great Lakes Basin Ecosystem. The Protocol has incorporated many of the elements which the Commission identified as essential components of such a strategy. These commitments, along with many national and regional domestic programs, provide a sound framework for such a strategy. However, concerted effort on a binational basis is required to provide the linkages between and among

these various elements to deal effectively and efficiently with toxic chemical contamination. While recognizing the commitments made under the Protocol, the Commission further recommends that:

4. *the Parties, in conjunction with the jurisdictions, develop and implement a Binational Toxics Management Strategy for the Great Lakes Basin Ecosystem to guide Canadian and United States domestic initiatives and to ensure that a more cooperative and coordinated approach is taken in response to the commitments made under the Protocol.*

Environmental Legislation

The Governments of Canada and the United States have recently passed or renewed several major pieces of legislation which, it is hoped, will contribute to achieving the goals and purpose of the Great Lakes Water Quality Agreement. The Commission commends these actions of the Parties and jurisdictions and encourages their effective and timely implementation. Some of these initiatives are highlighted in this section.

The major new piece of Canadian federal legislation is the Environmental Protection Act, which provides the legislative framework for improved management of chemicals. Through this Act, all chemicals - both existing and new - can be regulated at each stage of their life cycle from research and development to introduction, manufacturing and transport, distribution, use and disposal. This life cycle approach should provide a useful mechanism for better environmental management of existing chemicals and for alleviating potential toxic chemical problems.

Recent legislation in the United States that will assist in meeting commitments under the Agreement include the Safe Drinking Water Act Amendments of 1986, the renewal and reauthorization of Superfund for the control of hazardous wastes and their disposal sites, and the United States Water Quality Act of 1987. Highlights of the legislation are: the requirement to regulate many more contaminants in public water supplies than is now done; an emphasis on remedial actions to protect human health and the environment that use cost effective measures, are permanent solutions to the maximum extent possible, and can exploit alternative technologies and resource recovery technologies; a confirmation of the role of U.S. Environmental Protection Agency's Great Lakes National Program Office and its responsibilities under the Agreement and other related activities; the establishment of a Great Lakes Research Office within the National Oceanic and Atmospheric Administration to develop an environmental research program and data base for the Great Lakes system; and a five-year study and demonstration program carried out by the Great Lakes National Program Office for the control and removal of toxic pollutants in the Great Lakes,

with emphasis on the removal of toxic pollutants from bottom sediments.

In June 1986, the Province of Ontario announced its proposed Municipal/Industrial Strategy for Abatement (MISA), to reduce pollutants in effluent discharges from industrial sources and municipal wastewater treatment plants. The goal of the strategy is the virtual elimination of persistent toxic substances from discharges to the province's waterways.

Each of the Great Lakes states has moved to revise water quality standards, incorporate controls for toxic chemicals in pollution discharge permits, upgrade air quality requirements and increase protection for groundwater. In March 1988, Ohio passed a new law banning high phosphate detergents in counties bordering the Great Lakes. This is a milestone for the Great Lakes since, for more than a decade, the Commission has urged all Great Lakes jurisdictions to implement legislation to reduce the phosphate content of detergents to help achieve the phosphorus loading goals to the lakes in order to minimize eutrophication problems. Pennsylvania is now the only state that has not passed and implemented appropriate legislation.

In general, these legislative initiatives appear to be consistent with achievement of the general and specific objectives of the Agreement. However, the response to this fundamental commitment needs to be strengthened. The Commission calls attention of the Parties to the provisions of Article V of the Agreement which states: "Water quality standards and other regulatory requirements of the Parties shall be consistent with the achievement of the General and Specific Objectives. The Parties shall use their best efforts to ensure that water quality standards and other regulatory requirements of the State and Provincial Governments shall similarly be consistent with the achievement of these Objectives."

Other Initiatives and Activities

Several current activities undertaken on a bilateral or multilateral basis also contribute to achieving the goals and objectives of the Agreement. The Commission, although not directly involved in these activities, has observed their progress and awaits their outcome.

The Upper Great Lakes Connecting Channels Study, which commenced in 1984, is a joint Canada-United States activity focusing on toxic chemicals in the aquatic environment. No results had been reported as of December 31, 1988, but the information assembled over the four-year study period should be beneficial to the development of Remedial Action Plans for the St. Marys, St. Clair and Detroit Rivers.

The Niagara River has also received considerable attention in recent years. In 1981, the Commission completed a special report to Governments on the problems of the Niagara River. This report served as stimulus for the development of cleanup and rehabilitation programs on the river. In October 1986, the environmental agencies of Canada, the United States, Ontario and New York agreed to a four-party Niagara River Toxic Management Plan, using domestic laws and regulations to reduce the loadings of toxic chemicals to the Niagara River. In February 1987, the four parties signed a declaration of intent to reduce loadings of persistent toxic chemicals by 50 percent by 1996. The Niagara River Coordinating Committee briefed the Commission on progress under the plan in December 1988.

Under the 1987 Declaration of Intent, the four parties agreed to initiate activity on a Lake Ontario Toxics Management Plan compatible with IJC activities. A draft of the plan has been completed, and public meetings were held to obtain comments. Agreement on a final plan was completed in early March, as this report goes to press.

As indicated on page three of the Commission's Third Biennial Report, other initiatives such as the Great Lakes Charter, The Toxic Substances Control Agreement and, more recently, discussion of a Great Lakes Protection Fund, enhance cooperative efforts at the state and provincial levels. These arrangements provide frameworks compatible with the objectives of the Agreement, and can provide further encouragement to the participating agencies to pursue the binational intent of the Agreement.

Control of Point Sources of Pollution

onsiderable sums of money have been spent over the past two decades by the Parties, jurisdictions, municipalities and industries to construct and operate municipal and industrial wastewater treatment facilities. In addition, numerous regulations have been developed and implemented to control discharges from municipal and industrial point sources. In its 1987 report, the Water Quality Board reported on municipal and industrial performance in terms of compliance with domestic permits and regulations. These figures are of little value to the Commission in assessing progress with respect to point source performance for the reasons expressed on pages nine and ten of the Commission's Third Biennial Report. The Commission reiterates its recommendation that:

5. *the Parties and jurisdictions develop appropriate measures for reporting and assessing point source performance in relation to the Great Lakes Water Quality Agreement.*

For point sources of phosphorus, monitoring of municipal and industrial sources provides important information to evaluate progress towards meeting the phosphorus target loadings specified in Annex 3 of the Agreement. In the 1983 Phosphorus Load Reduction Supplement to Annex 3, the Parties agreed that priority would be given to "continuation and intensification of efforts to ensure that municipal waste treatment facilities discharging more than one million gallons per day achieved an effluent concentration of 1 mg/l total phosphorus on a monthly average." They also agreed that "reasonable and practical measures will be undertaken to control industrial sources of phosphorus." While significant improvements have been achieved in both areas since 1972, some municipal facilities still do not meet the 1 mg/l effluent requirement. This is particularly critical if the Parties are to meet the phosphorus load reductions agreed to in the Agreement. The Commission recommends that:

6. *the Parties and jurisdictions intensify efforts to ensure compliance of municipal waste treatment facilities with the 1 mg/l effluent concentration of total phosphorus and report compliance on a monthly basis.*

Industrial sources also are important contributors to the total phosphorus loadings to the lakes. The Commission supports the Water Quality Board's recommendation that jurisdictions require phosphorus effluent monitoring in all industrial facilities which have the potential to discharge over one metric ton of phosphorus per year.

For metals and many organics, some point sources are not under control with respect to existing requirements. Moreover, additional discharge limitations are required, particularly to control toxic organics. Additional information on the presence and quantity of persistent toxic substances in point source effluents is needed in order to allow for greater control over these sources. Although progress is being made, the Commission feels that there is room for improvement and acceleration of effort. In accordance with the goal of zero discharge and the intent to virtually eliminate the input of persistent toxic substances, the Commission recommends that:

7. *the Parties and jurisdictions accelerate programs and initiatives to assure better quantification of toxic chemical loadings from municipal and industrial sources and to minimize their release.*

Many municipal wastewater treatment plants throughout the basin receive contaminated industrial wastewaters that are discharged to the municipal sewer system. Although treatment processes for conventional pollutants remove limited quantities of toxic heavy metals and organics, their large-scale removal requires special processes.

In both countries, programs to pretreat industrial wastes which are discharged to municipal systems but are not amenable to standard sewage treatment processes are being developed. Characterization and quantification of these discharges requires substantial effort, and a data management system is required to evaluate the effectiveness of compliance by municipalities and industrial users. In order to meet the pretreatment requirements of Article VI of the Agreement, the Commission recommends that:

8. *the Parties and jurisdictions provide sufficient resources and, where necessary, accelerate program development and implementation to meet the pretreatment requirements of Article VI of the Agreement.*

Many treatment plants only transfer pollutants from effluents to sludges, leaving a major problem of sludge handling and disposal. While much attention has been directed to this problem, more intensified effort is needed to improve waste management and sludge disposal practices so they are more environmentally acceptable. Intensified efforts in process modification, product substitution, waste and byproduct recycling and exchanges are required as alternatives to disposal of wastes in landfills.

Control of Nonpoint Sources of Pollution

In the early years of the Agreement, pollution control programs focused on point source controls and detergent phosphorus limits as the means to reduce phosphorus inputs to the lakes. The 1978 report of the Pollution from Land Use Activities Reference Group (PLUARG) showed that nonpoint sources, mainly agricultural and urban runoff, contributed about half the nutrient phosphorus to the lower lakes, and that atmospheric sources contributed phosphorus inputs as well. PLUARG also pointed out that nonpoint source control measures offered a cost effective alternative to more stringent point source controls for limiting phosphorus. PLUARG did not address the inputs and impacts of toxic chemicals from nonpoint sources, except for a few specific pesticides, but the Commission did point out the potential for such pollutants from urban and hazardous waste disposal sites.

The 1978 Agreement recognized the role of nonpoint sources as contributors of pollution in nutrient reduction programs. Annex 3 of the Agreement called for the Parties to confirm future phosphorus loads and to establish load reduction allocations and compliance schedules. A Phosphorus Load Reduction Supplement to Annex 3 was signed by the Parties in October 1983. The supplement confirmed the target loads and called for the development of load reduction plans for Lake Erie, Lake Ontario and Saginaw Bay. Many delays in the development of phosphorus load reduction plans meant that they were not submitted to the

Commission by the United States Government until late 1986 and by the Canadian Government until 1987. At the time of this report, the plans are still under review by the Water Quality Board. The Board is assessing the adequacy of the plans to meet the intent of the Phosphorus Load Reduction Supplement and its goals.

Despite intentions, it would appear from reports of the Water Quality Board that programs in both countries have fallen behind schedule and risk being compromised by other priorities. Further, the determination of loading estimates is being complicated by shortcomings in tributary monitoring for phosphorus and other substances. The control of nonpoint sources of phosphorus to the Great Lakes is an obligation of the Parties under Annex 3.

The United States plan relies, for the most part, on management techniques and educational efforts rather than on major new programs requiring large capital outlays. The total load reduction of 1,800 tons per annum for Lake Erie and 225 tons per annum for Saginaw Bay are to be achieved by accelerating existing programs to control soil erosion and reduce nonpoint sources of phosphorus. The Commission notes the comment of the Water Quality Board that recent United States legislation may result in the diversion of funds to higher priority areas (more erodable lands) outside the Great Lakes basin.

In Canada, a reduction of 200 tons of phosphorus inputs to Lake Erie will be met by improved soil management and conservation practices. The primary driving force for improved practices is the joint federal-provincial Soil and Water Environmental Enhancement Program (SWEEP), which is now operational and builds on the PLUARG approach of interagency cooperation. The Commission encourages Canadian authorities to continue support for this initiative and ensure that it is adequately funded.

The situation for Lake Ontario is less clear. In 1985, the Canadian portion of the Lake Ontario target load was reduced to a level that Canada has suggested lies within the estimation error, and thus may not require additional remedial programs. The Commission urges Canada to implement whatever programs are needed to meet the agreed target loads. The United States has reported that it will achieve its contributed reduction in the target load by accelerating existing extension programs on priority watersheds. Efforts to achieve the targeted loadings must be maintained, despite the current emphasis on toxic chemicals. The Commission therefore recommends that:

9. *the Parties implement programs required to meet target loads for phosphorus and accelerating, if necessary, the current rate and priority of implementation in each jurisdiction.*

The Commission awaits a report from the Parties on their review of the effectiveness of their programs to achieve target loads, which is required under the Supplement to Annex 3.

Although PLUARG studies focused mainly on phosphorus and a few pesticides, nonpoint sources also contribute significant loadings of toxic chemicals to the lakes. Agricultural sources are a concern not only because of runoff of pesticides and other chemicals used on farms, but also due to contamination of groundwater. Even erosion control measures such as conservation tillage may, paradoxically, contribute to increased toxic substance use through the application of added amounts of herbicide in place of disturbing the soil. Urban sources include urban runoff, urban pesticide use, illegal dumping, combined sewer overflows, spills and fugitive emissions such as the runoff from dumps and stockpiles. As noted in the PLUARG studies and in previous Commission biennial reports, good management practices are very important in alleviating the contribution of many of these nonpoint sources, and current regulatory approaches must include such practices. New disposal and recycling technologies should also be an important element.

Land use sources of toxic pollutants are significant in 28 of the 42 Areas of Concern, and will have to be addressed in the development of Remedial Action Plans. At present, little is known about the overall flows of toxic pollutants from nonpoint sources. The Water Quality Board has begun an assessment of pesticide use in the Great Lakes basin and will assemble overlay maps of soil types and geology to illustrate the intensity of pesticide use and application, and to provide a basis upon which to estimate the impacts of pesticides on surface waters. The Board is also reviewing models which attempt to predict the fate and transport of contaminants from agricultural and urban land use. This activity and the various initiatives identified in Annex 13 of the revised Agreement may lead to a much better understanding of nonpoint sources of pollution to the Great Lakes system. The Commission recommends that:

10. *the Parties and jurisdictions ensure that adequate procedures are developed and funding is made available for the characterization and assessment of nonpoint source contaminant loadings to the Great Lakes and that appropriate controls are developed and implemented.*

Contaminated Sediments

In its Third Biennial Report, the Commission recommended that the Parties increase efforts to develop and implement comprehensive sediment management programs and initiate increased research to address the knowledge gaps inhibiting the management of sediments in the Great Lakes system. The Parties have

responded by incorporating an annex into the revised Agreement which is aimed at identifying the nature and extent of sediment pollution, its impact on the system and technological capabilities to remedy such pollution.

Traditionally, contaminated sediments have been addressed only in the context of navigational dredging and disposal projects. Both the 1972 and 1978 Agreements recognized the need for better management of dredged spoil and, under the auspices of the Commission, criteria for classification of dredged spoil and for disposing of spoil were developed in 1983. These criteria have not been formally adopted by the Parties, but the Commission has been advised by the Parties that their guidelines for evaluating dredging projects are consistent with the Great Lakes dredging guidelines.

With increasing recognition that contaminated sediments have an impact on water chemistry and associated biota, the maintenance of an accurate and consistent data base on dredging activities is important. In recent years, the Commission has encountered difficulty in maintaining the register under Annex 7, due in part to a lack of timely reporting of data. The Commission recommends that:

11. *the Parties ensure that improved mechanisms are put in place for the timely reporting of accurate data and statistics on dredging activities to enable maintenance of the Dredging Register called for under Annex 7 of the Agreement.*

The Water Quality Board reported in 1987 that comprehensive, basinwide sediment contaminant surveys for open lake portions of the Great Lakes have generally been neglected since the late 1960s and early 1970s. Existing data suggest that elevated contaminant levels occur in sediments throughout most of the Great Lakes basin. Sediment movement is a natural phenomenon, and the extent of migration of contaminated sediments and their impact on the health of the ecosystem are virtually unknown.

Contaminated sediments occur in 41 of the 42 currently identified Areas of Concern and likely exist in other areas of the basin. As indicated in the Agreement, information obtained through research and studies pursuant to Annex 14 shall be used to guide the development of Remedial Action Plans and Lakewide Management Plans. The Commission welcomes the increased emphasis in the Agreement for managing contaminated sediments and emphasizes the urgency of additional research and technology assessment to enable remedial actions for contaminated sediments to be undertaken with the least possible impact on the ecosystem. The Commission recommends that:

12. *the Parties, in cooperation with the jurisdictions, accelerate the development of programs related to research, development and demonstration, and implementation of remediation technologies and ensure that adequate resources are made available to meet the commitments made with respect to managing contaminated sediments in the Great Lakes Basin Ecosystem.*

A well coordinated network of demonstration projects could provide much of the scientific basis needed for many of the Remedial Action Plans. In essence, individual demonstration projects could serve as controlled scientific experiments to test and evaluate selected remedial options, and to shed light on underlying processes.

Restoration of Areas of Concern

Since 1974, the Commission has consistently reported a lack of action in cleaning up a number of more seriously polluted locations in the Great Lakes basin. In its Third Biennial Report, the Commission reported that progress had been made through the designation of 42 Areas of Concern, and the commitment by the various jurisdictions to develop Remedial Action Plans to restore beneficial uses in these areas.

By incorporating the Remedial Action Plan (RAP) process into the revised Agreement, the Parties have committed themselves to cooperate with state and provincial governments to ensure that Remedial Action Plans are developed and implemented for each Area of Concern. In addition, the Parties assume the responsibility, in cooperation with the state and provincial governments and the Commission, to designate Areas of Concern.

The Agreement requires that Remedial Action Plans embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses and outlines the expected content of each RAP. The Commission commends the Parties and the jurisdictions for their response to a very ambitious and promising initiative, which will lead to significant improvements in the water quality of local areas and beneficial results for the Great Lakes ecosystem as a whole. Although lead responsibility for development of RAPs rests with the Parties and the jurisdictions, the Commission will remain actively involved in the RAP process by recommending the designation of new Areas of Concern and reviewing and commenting on Remedial Action Plans at the stages outlined under Annex 2, paragraph 4(d). Further, the Commission will monitor progress in the development of individual RAPs and in addressing problems in Areas of Concern.

The Commission believes that successful remediation of Areas of Concern depends on the full and effective involvement of all stakehol-

ders. In Annex 2, the Parties commit themselves to ensuring, in cooperation with state and provincial governments, that the public is consulted in all actions undertaken pursuant to the Annex. In areas such as Green Bay, the Rouge River and Hamilton Harbour, successful programs of community involvement have stimulated a strong interest and commitment on the part of governments, industries and citizens to restoring local environmental quality.

The Remedial Action Plan process has created broad-based enthusiasm and momentum for cooperative, definitive actions to restore beneficial uses in Areas of Concern. While considerable progress has been made in many of the areas, a lack of commitment in some areas has resulted in little progress. The Commission recommends that:

13. *the Parties ensure that each of the jurisdictions establish appropriate timetables to develop Remedial Action Plans in accordance with the requirements of Annex 2 and identify achievable intermediate goals or milestones as tangible measures of progress to complete restoration.*

The present list of designated Areas of Concern does not, in the Commission's opinion, cover all of the sites or geographic areas requiring attention. To enable the Commission to provide advice in this regard, the Water Quality Board and the Science Advisory Board are developing criteria for the Commission to use in assessing when an area should be recommended to Governments for designation, or when a designated area should be removed from the list because impaired uses have been restored.

The complexity of the problems in many of the Areas of Concern has caused significant delays in the original timetables established by the jurisdictions for completion of Remedial Action Plans. However, the Commission recognizes that there has been progress despite many delays, and recommends that:

14. *the Parties, in cooperation with the jurisdictions,*

(a) *continue to focus priority attention on development and implementation of Remedial Action Plans for the 42 currently identified Areas of Concern.*
(b) *develop procedures for listing and delisting Areas of Concern, and for measuring progress with respect to restoring Areas of Concern.*
(c) *identify and designate those locations in the Great Lakes basin which qualify as Areas of Concern based on these criteria.*

As of December 31, 1988, the Commission has received ten RAPs for review and comment. The Commission has established a process in order to fulfill its obligation to provide comments on the RAPs. The process includes reviews by the Water Quality Board, the Science

Advisory Board, the Great Lakes Fishery Commission and other interests. The review criteria at present being used by the Water Quality Board and the Science Advisory Board are outlined in Appendix B. As principal advisor to the Commission under the Agreement, the Water Quality Board will coordinate the Commission's review of RAPs and will assemble the comments of the various reviewers into a summary report for the Commission's consideration. On receiving a completed review, the Commission will consider the summary report and supporting documentation in the context of the following general criteria:

- are the advice received and the RAP itself consistent with Agreement requirements?
- are there discrepancies among sources of advice and how should they be dealt with?
- do additional policy dimensions require attention?
- are the review and advice consistent with other RAP reviews?
- has the public consultation process been adequate?

The Commission's comments, based on its review, will be forwarded to the Parties and to the respective jurisdiction.

Pollution from Shipping Sources

Under the terms of the Agreement, the Canadian and United States Coast Guards and interested agencies meet annually to consider Annexes 4, 5, 6, 8 and 9. The two Coast Guards submit an annual report to the Commission on their consultations.

Information provided in the Coast Guards' annual reports includes data on the numbers of reported pollution spill incidents in the waters of the Great Lakes system from shipping and non-shipping sources. As expected, the number of spills varies annually as does the severity of individual incidents and the costs of cleanup efforts. The reports suggest that there have been no major spills over the past two years. The significance of spill data has not been assessed, but the importance of this source of contaminants must be assessed in pursuing the mass balance approach for contaminant loadings.

The Commission notes improvements in the Joint Canada-United States Contingency Plan developed pursuant to Annex 9 and supports the need for joint response teams to hold periodic exercises and meetings.

As indicated earlier in the report, the introduction of exotic species

to the Great Lakes from the discharge of ballast water of ships is an issue that has received increased attention over the past year. The Commission has expressed its concern to Governments about this problem and encourages them to expedite controls which ensure that this source of contamination to the system is curtailed. The Commission believes that sufficient studies have been conducted to confirm the threat that this pollution source poses to the Great Lakes and that action is required.

Surveillance and Monitoring

Great Lakes International Surveillance Plan

Various agencies in Canada and the United States undertake surveillance and monitoring activities to determine the effectiveness of pollution abatement programs implemented pursuant to the Agreement. The Great Lakes International Surveillance Plan (GLISP), proposed by the Water Quality Board in its 1975 annual report and subsequently revised, provides a bilateral, comprehensive framework for coordinating these responsibilities. Annex 11 of the Agreement outlines the basic purposes of surveillance and monitoring and commits the Parties and jurisdictions to develop and implement joint surveillance and monitoring programs necessary to attain Agreement purposes, using GLISP as a model. Joint monitoring programs provide the foundation for assessments of progress in achieving the objectives of the Agreement. Without a firm foundation of both historic and current data, neither the Parties nor the Commission can adequately assess the condition of the Great Lakes ecosystem or the effectiveness of programs to achieve the goals of the Agreement.

Although the Commission has contributed extensively to the identification of program elements through the development of GLISP revisions, the Parties are responsible for defining and developing appropriate monitoring programs in cooperation with the states and provinces. There are indications that necessary elements of the plan have not been implemented, resulting in data gaps and incompatibility of data between the jurisdictions. The Commission recommends that:

15. *the Parties, in cooperation with the jurisdictions,*

(a) *continue to develop and implement joint surveillance and monitoring programs which are compatible with the Great Lakes International Surveillance Plan;*
(b) *identify current monitoring and surveillance activities that are particularly important to information needs under the Agreement, and ensure that these activities are supported in the common interests of both countries;*
(c) *consider the development and designation of specific Agreement core monitoring networks as international monitoring networks;*
(d) *agree on consultation procedures to be followed prior to reaching deci-*

sions on the reduction or elimination of activities identified or networks designated under the above.

Integrated Monitoring

Various government and industrial environmental monitoring programs must respond to increasing demands for environmental data. Data collection programs tend to be narrowly structured to meet specific needs, with information collection often on a one-time, one-user production format. On the other hand, multiple entities at various levels often collect similar data, resulting in redundancies and overlaps, data incompatibilities, and other problems such as data which are neither readily available nor usable for other purposes.

Increased effectiveness and efficiency in monitoring can be achieved within existing monitoring and surveillance programs by making selected sites in existing networks or new integrated sites combine the various monitoring and measuring requirements for several environmental media (air, surface and groundwater, soil, vegetation, precipitation, etc.) at a single location with a single operational control. The Commission therefore recommends that:

16. *the Parties and jurisdictions work cooperatively to make existing monitoring sites more multifunctional and to develop new integrated monitoring sites as part of their joint monitoring and surveillance program.*

Annex 12(5) addresses the need for an early warning system to anticipate toxic substances problems. An important component of an early warning system is the ability to perform various kinds of retrospective analyses to consider formerly unstudied or newly identified toxic substances. Retrospective analysis depends on the availability of suitable archived materials. Archive operations such as specimen banks are not basic parts of Great Lakes monitoring and surveillance programs. Accordingly, the Commission repeats its recommendation from the Third Biennial Report that:

17. *the Parties implement programs to permit retrospective analysis of environmental problems, including specimen banking for biological tissue and sediment, as an integral part of their joint monitoring and surveillance program.*

Atmospheric Monitoring

An integrated monitoring system should include components to assess atmospheric quality and the effects of atmospheric processes on water quality. In Annex 15, the Parties commit themselves to establish an Integrated Atmospheric Deposition

Network to determine atmospheric loadings of toxic substances to the Great Lakes system and to define the temporal and spatial trends in the atmospheric deposition of persistent toxic substances. The Parties also agree, in cooperation with state and provincial governments, to "conduct research, surveillance and monitoring and implement pollution control measures for the purpose of reducing atmospheric deposition of toxic substances, particularly persistent toxic substances, to the Great Lakes Basin Ecosystem."

Very few airborne toxic substances are routinely measured. To meet these new commitments, the Parties must significantly expand the number of airborne substances being monitored. In so doing, they can take advantage of a rapidly developing and comprehensive theory of the behavior and transport of atmospheric substances, significant advances in the use of computers and the state of modeling, and improved sampling instrumentation and analytical methods for airborne substances. These components will all aid in the expansion of atmospheric programs.

The management of air quality, especially in defining its geographic boundaries, has often led to a concept of "airshed" analogous to that of a "watershed." While such a concept has theoretical value, it is of limited practical value in the Great Lakes region. The Commission's International Air Quality Advisory Board has proposed a concept with more tangible attributes: the "atmospheric region of influence." This is a region bounded by distances associated with average travel times of air masses to a given site. Using the vast and highly standardized meteorological data bases of the United States and Canada, such regions can be defined for almost any part of North America.

Under Annex 15, the Parties' immediate task is to report on consultations on the components of an Integrated Atmospheric Deposition Network, including identification and agreement on parameters to be monitored, number and location of monitoring sites, equipment at sites, quality control and quality assurance, and site construction and operation schedules. The Commission believes that the concept of atmospheric region of influence has merit and that such a region should be defined with respect to the appropriate atmospheric networks indicated in Annex 15.

The atmospheric imports, exports and storage components of mass balances for various environmental elements typically reflect great uncertainties. The comparable uncertainties for other environmental compartments (e.g. groundwater, biotic reservoirs, sediments, etc.) are also great but rarely approach those of the atmospheric component. As most modeling strategies for describing transport, behavior and effects on receiving systems of atmospheric pollutants begin with mass balances, the Parties should review existing programs at locations with

integrated monitoring and examine mass balance approaches when deciding on priorities and thrusts for programs to support Annex 15. The existing programs operate on a variety of geographical scales ranging from regional to continental and global and including a variety of time scales. The Commission believes that programs in support of Annex 15 should be harmonious with these other existing programs. The Commission welcomes the Parties' commitment to establish an Integrated Atmospheric Deposition Network and recommends that:

18. *the Parties consider the adoption of the concept of an "atmospheric region of influence" in their planning and design of activities under Annex 15 of the Agreement.*

Groundwater

Annex 16 concerns groundwater and contains commitments to map hydrogeological conditions, analyze sources of contamination, provide standard approaches and procedures in sampling and analysis of groundwater, and control sources of contamination of groundwater as well as contaminated groundwater itself. The mapping requirements and standardized approaches and procedures recommended in prior biennial reports are essential for management and monitoring of groundwater resources. Newly emerging information suggests interrelationships between atmospheric pollution and groundwater contamination, lake and river sediment contamination and groundwater as a source of pollutants to the Great Lakes. The Commission welcomes the inclusion of an Annex on contaminated groundwater in the amended Agreement and recommends that:

19. *the Parties and jurisdictions ensure that groundwater monitoring and surveillance activities are, to the extent practical, incorporated within their integrated monitoring strategies and programs.*

Radioactivity

In 1986, the world was stunned by the explosion and fire at the Chernobyl nuclear power plant in the Soviet Union and the subsequent spread of radioactive debris over much of the globe, including the Great Lakes region. This as well as other events have attracted public attention to the dangers of accidental releases and "unscheduled" emergency releases from nuclear facilities. Virtually any emission of radionuclide material in the "atmospheric region of influence" of the Great Lakes could affect the integrity of the Great Lakes ecosystem. In the Great Lakes basin itself, there are sixteen nuclear power plants with as many as eight reactors each, one nuclear materials refinery, and one combination mining area and refinery from which unscheduled releases are possible.

From 1976 to 1980, the Water Quality Board reported annually on radioactivity emissions and ambient levels in the Great Lakes basin. After 1980, this reporting ceased. In 1983, the Water Quality Board briefly updated information on radioactivity in its Appendix B review of monitoring and surveillance.

The Commission's need for consistent and continuous reporting on radioactivity in the Great Lakes relates to the Agreement's emphasis on toxic and hazardous materials, and the Parties' own policies of defining all radioactive substances as toxic and hazardous.

The Commission discussed radioactivity in its Third Biennial Report, and affirmed support for the Agreement objective on exposure to radioactivity. The Commission also recommended that information on the type of radioactivity (alpha, beta and gamma) be augmented with data on specific isotopes, and briefly discussed the problems of disposal site shortages for the low-level radioactive wastes from civilian, nonpower production uses of radioisotopes.

The Parties need to review and upgrade their entire radioactivity monitoring effort to include monitoring and reporting on the isotopes and their levels in unscheduled releases. The Commission notes the Water Quality Board has proposed general monitoring for radioactivity be undertaken every five to ten years. The Board justifies its approach on the long existences of the three major isotopes of concern: tritium, plutonium and americium. The Commission also supports additional monitoring following all unscheduled releases and incidents. Therefore, the Commission recommends that:

20. *the Parties institute the Water Quality Board's recommended monitoring protocol, develop the capacity for intensive monitoring of atmospheric, aquatic and biological components following every unscheduled release of radioactivity and that information resulting from these monitoring activities be communicated to the Commission.*

Data Management Under the Agreement

Quality assurance and quality control must apply to many data gathering and analysis activities under the Agreement. The Water Quality Board is reviewing a recent two-year study of the quality assurance/quality control practices of various agencies and groups associated with Great Lakes monitoring and surveillance activities. The Commission believes that Great Lakes surveillance and monitoring programs require integrated and consistent quality assurance/quality control policies and protocols in order to ensure proper assessment of the overall effectiveness of the programs and measures undertaken pursuant to the Agreement.

The Commission has traditionally used as its main source whatever data the Parties and jurisdictions provided. Time and resources are consumed to complete, correct and interpret those data to allow even the most elementary of comparisons and analyses. The data received are often inaccurate and incomplete, and, as discussed in the Third Biennial Report, much of the data is not helpful in assessing how well the Parties are achieving the goals and purposes of the Agreement. A specific example cited was, and continues to be, information on limits on discharges in various permits and control orders, and how those limits relate to specific objectives under the Agreement and the ecological responses of Great Lakes biotic communities.

The Commission is also concerned about the format in which data are received. A major portion of the Commission's costs of data analysis relates to putting diverse types of data into appropriate formats for processing. Given the increased demands on its limited resources, the Commission cannot continue to assess the condition of the Great Lakes ecosystem without significant improvement to the Parties' and jurisdictions' current data management practices. To alleviate this problem, the Commission has pointed out to Governments the importance of ready accessibility to suitable data to meet the Commission's analytical requirements (see Appendix A) and has asked its boards to consider the matter so as to specify more precisely the Commission's needs.

Many data quality problems reflect poor housekeeping: the need to assure correct labeling of specimens, to keep neat records, to record observations and transcribe numerical information carefully. Environmental data banks provide opportunities to annotate data with remarks on data quality and limitations, but data providers have not tended to take advantage of these important opportunities. Managers of archiving, maintenance, retrieval and use of environmental data in various data banks should ensure that all component data sets in the data bank have appropriate commentaries on data quality problems or limitations, and that data are correctly transcribed from original sources during the archival process.

An assessment of the condition of the lakes cannot be any better than the information on which it is based. Assembling and analyzing available information require comparative and integrative studies of multiple data sets from several investigators, with data collected at different times and possibly under different protocols. Studies of multiple data sets raise issues of data comparability and compatibility, as well as the treatment of outliers (data elements which have excessively high or low values relative to some perceived behavior of other data being collected). Various Commission-sponsored studies continue to reveal wide variances in accuracy, consistency and form. Furthermore, there are problems with obtaining data in a timely manner due to

lengthy delays in the Parties' and jurisdictions' own data verification processes. Therefore, the Commission recommends that:

21. *the Parties and jurisdictions review the data required for implementation of the Agreement and develop a mechanism for ensuring that it is supplied in a timely manner and consistent with quality assurance and compatible data management requirements of Annex 11.*

The Commission's concerns about the effectiveness of its future assessment work also suggest the need for the development and implementation of a policy for data management by the various agencies of the Parties and jurisdictions which is responsive to goals expressed in the Agreement. At present, agency priorities and policies may not result in data which are compatible with achieving the goals and purposes of the Agreement. Therefore the Commission recommends that:

22. *the Parties develop a data management policy with clearly articulated goals that reflect specific data needs responsive to the Parties' commitments under the Agreement, and that the Parties and jurisdictions review their data management programs and ensure that they are consistent therewith.*

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III. SCIENCE AND AGREEMENT PROGRAMS

Relating Observed Pollutant Loadings to the Condition of the Great Lakes

The integration of chemical and biological data to relate observed levels of pollutants to effects on the ecosystem traditionally have used specific objectives for single chemicals, developed at least in part through reviews of toxicological data. The use of specific objectives has led to an inaccurate perception that such objectives define ecologically safe levels of chemicals. Rather, specific objectives are guides based on applying a safety factor to the levels of pollutants at which selected undesirable effects have not been observed. When new research and information suggest that observed levels of "no effect" differ from those previously used to develop an objective, the objective is subject to change. One example is lead and its effects on human health. Recent studies show observable adverse biological effects at continuously decreasing levels of exposure.

The quantification of chemical doses and loadings which cause disease, deformity, or impaired reproduction and survival is difficult. Translating that information into control programs is even more difficult when the trends in chemical levels in the environment are not clear or show a leveling off uncorrelated with observed ecological effects. Such a situation exists in some data for toxic residues in various environmental compartments of the Great Lakes, as was indicated earlier in this report. Further, it is not usually clear how and to what degree to establish the required level of ecosystem protection or restoration as a basis of determining desired levels of input reduction. Consequently, the Commission recommends that:

23. *the Parties establish the linkages between loadings, ambient concentrations and ecosystem responses, in order to stimulate various source reduction strategies and understand better their effects.*

Human Health

The revised Agreement explicitly recognizes that humans are an important component of the ecosystem and the protection of their health is a worthy goal in its own right. Annex 12(6) of the Agreement calls for the Parties to "establish action levels to protect human health based on multimedia exposure and the interactive effects of toxic substances."

To date, activities of the Commission's Human Health Effects Committee, which reported jointly to the Water Quality Board and Science Advisory Board until mid-1988, focused on epidemiological methods, standardization of various disease registries, evaluation of the toxicological data and risk to human health from chemical contaminants found in various Great Lakes compartments, and fish consumption and

drinking water advisories. It also collected and organized a diverse data base needed to perform exposure assessments and the preparation of toxicological information sheets for individual chemicals.

The increased importance given to human health in the Agreement and the high level of general concern have led the Commission to instruct its boards to give high priority to human health issues. The Science Advisory Board has established a new Health Committee to provide advice to the Commission in the following areas:

- interpret and advise on public policy as related to the human health aspect of environmental quality problems in the Great Lakes Basin Ecosystem;
- assess the current state of knowledge and data gaps on exposure through all media of humans to toxic contaminants;
- evaluate the relationships between exposure to potentially hazardous substances or agents and human health status;
- develop a framework on the utility of an integrated assessment of biological markers;
- advise on the development of a comprehensive approach for monitoring and surveillance of human exposure, and for research on early markers of indicators and effects; and
- advise on the development of strategies for disease prevention and health promotion by reduction or elimination of both direct and indirect exposure to potentially hazardous substances or agents to humans.

The Commission will be devoting more attention to programs related to human health in future reports and recommends that:

24. *the Parties give high priority to human health considerations and support research to understand the impact on human health of chronic exposure to small amounts of toxic contamination.*

Health Advisories

Some jurisdictions advise their citizens — and thereby attempt to protect human health — by issuing health advisories on the consumption of drinking water and fish from selected sources. Fish advisories have been and continue to be a source of some controversy. Fish advisories are based on evaluating the risk associated with consuming fish containing residues of selected toxic chemicals at particular levels. These advisories primarily focus on the sport angler, the person who lives off the land and water, and selected population groups at high risk from toxic substances, notably pregnant women, nursing mothers and infants. Advisories generally indicate such information as species by age class and size, contaminant likely to be present,

and suggestions on allowable quantities and frequency of consumption or cautions against consumption altogether.

Differences in sampling approaches, models and calculation methods among jurisdictions have created problems in trying to provide a common basis for understanding and using advisories. Some jurisdictions sample whole fish; others sample certain filets or edible sections. Some methods assume uncooked fish; others consider fish cooked or prepared in a variety of ways, even how individual recipes might modify human exposure to the toxicant. An important difference found between advisories is the choice of risk factor. As this choice reflects the different perceptions of the citizens and governments of the various jurisdictions about safety and the nature of biological effects, the Commission has been reluctant to advocate use of a single methodology for fish advisories by all Great Lakes jurisdictions.

These inconsistencies were recognized in a 1982 report of a Commission workshop of the Water Quality and Science Advisory Boards ("Proceedings of the Roundtable on the Surveillance and Monitoring Requirements for Assessing Human Health Hazards Posed by Contaminants in the Great Lakes Basin Ecosystem"). The workshop participants recommended resolving the edible portion sampling issue by agreeing on a standard edible portion, or conducting research on the relationships between different portions of different species of fish such that data from different jurisdictions can be compared. The Commission recommends that:

25. *the Parties and jurisdictions evaluate the relationships between the various sampling and calculation methods for fish advisories, and develop an appropriate method to transform the values calculated by various jurisdictions to some common basis for understanding.*

Measuring Ecological Integrity

Although the effects on humans of only a few substances of interest found in the Great Lakes ecosystem have been evaluated, the health sciences have produced principles which apply to more than the immediate purpose of how various substances affect humans. In the Third Biennial Report, the Commission suggested using human health perspectives and biomedical approaches, including risk assessment methodologies and epidemiological studies, to assist in developing ecosystem health concepts and perspectives.

Ecological health is more than the absence of diseased components. It has many attributes, one of which — integrity — is a goal of the Agreement. Integrity in a narrow biological sense entails the assurance

that physiological processes are complete and functional within a living organism and between it and its environs. Taken more broadly, integrity can mean the wholeness and sustainability of a system. The Commission, through the Ecological Committee of the Science Advisory Board, has been focusing on ecosystem integrity and how to measure conditions with respect to it. To compare observed conditions with a natural state that is remarkable in its complexity and dynamics, some system of comparative measurement is needed.

A more comprehensive analysis of the integrity of the Great Lakes system could be accomplished if the following were available:

- more extensive data and information on the living components of the ecosystem through programs of biological monitoring;
- protocols which characterize the quality of the information; and
- scientifically supportable ecological criteria upon which to judge the relative values of evidence within an overall assessment of ecological health.

The Need for Ecosystem Benchmarks

The living communities in the Great Lakes Basin Ecosystem have been changing in composition through natural succession and as a result of various perturbations and the actions of humans. These changes are occuring rapidly in response to the quantities of stresses and the many synthetic materials new to the system's environment. The pervasiveness of synthetic chemicals and various other interventions in the Great Lakes have resulted in few sites in the system suitable to serve for comparative purposes as natural conditions or as standards of ecosystem integrity — places which demonstrate essential integrity of natural structures and processes.

Isle Royale and Long Point are two Great Lakes biosphere reserves which have potential as possible benchmark areas. They are part of the biospheric reserves of the International Man in the Biosphere Program, and both areas provide important information. For the most part, they have healthy biological communities, but their exposure to problems from atmospheric pollution may force a state of declining ecological health.

Two benchmark areas cannot adequately represent the many kinds of Great Lakes environmental systems. Accordingly, the Commission recommends that:

26. *the Parties develop a protocol for designating and protecting areas as benchmarks in the long-term evaluation of ecosystem integrity and the effectiveness of remedial measures within the Great Lakes Basin Ecosystems, and designate several areas in the basin.*

Biological Monitoring

Current monitoring and surveillance programs for the Great Lakes focus mainly on chemical parameters and are inadequate with respect to biological monitoring. Monitoring the integrity of an ecosystem requires monitoring the living components of that system. Chemical monitoring programs are usually easier to design and implement than biological monitoring programs, but they cannot replace the latter. Accordingly, the Commission recommends that:

27. *the Parties undertake programs of biological monitoring in addition to and integrated with programs of chemical monitoring.*

The effectiveness of biological monitoring depends on extensive knowledge of the physiology and ecology of chosen indicator species. A few research programs provide combined information on environmental chemistry, physiology and ecology. These are extremely valuable programs which should be maintained, and an appropriate level of funding and support should be established.

Most existing biological monitoring is limited to toxicity tests (bioassays) and chlorophyll measurements. Recent revisions of GLISP provide suggestions for some biological monitoring which, if implemented, would provide useful data. However, the Commission notes that consensus does not exist among Great Lakes monitoring and surveillance agencies on a basic, useful set of ecological measurements. Because a common set of ecological measurements would provide a stronger foundation for programs in biological monitoring, the Commission recommends that:

28. *the Parties agree on a set of ecological measurements to be used in biological monitoring programs to provide a basis for assessing the ecological condition of the Great Lakes ecosystem.*

Biological monitoring programs should include monitoring for diversity and trophic levels relationships.

Healthy biotic communities are diverse and contain a variety of species which exhibit a range of geographic distributions, frequencies of occurrence, age and size classes, and several different life stages. Highly diverse communities tend to be ecologically heathier than communities with low diversity. Ecological diversity is usually measured through indices which need to be carefully chosen to avoid statistical and theoretical limitations.

Current surveillance and monitoring programs are generally not designed to provide the data from which to evaluate ecological diversity. Accordingly, the Commission recommends that:

29. *the Parties and jurisdictions, in developing their monitoring programs, ensure that the programs provide adequate data to assess the ecological diversity of the Great Lakes ecosystem.*

Information on Ecological Pathways and Trophic Levels

Two recent Science Advisory Board workshops examined selected aspects of energy and nutrient use in the Great Lakes ecosystem through the perspective of foodweb dynamics. The workshops addressed the behavior of certain trophic levels, or groups of organisms which collectively perform a common ecological role. From these workshops, the Commission notes that treating some parts of the foodweb in isolation from others may yield incorrect conclusions for some Great Lakes communities.

Some surveillance and monitoring information has suggested the absence of selected environmental compartments, and therefore certain trophic levels, from the ecosystem. For example, the absence of top predators — notably certain mammals and raptorial birds — in many Great Lakes areas might suggest a missing trophic level. Two factors generally explain missing trophic levels in the Great Lakes system: a lack of suitable habitat for selected organisms and high levels of toxicity in environmental compartments.

The trophic levels most often ignored or not reported on in Great Lakes studies are the benthos (bottom organisms) and the detrital decomposition system. Open lake benthos have not been studied in over a decade. Benthic studies assume new ecological importance because many Areas of Concern have polluted sediments, and because the Protocol incorporated into the Agreement a benthic organism as an ecosystem indicator.

An assessment of the condition of the Great Lakes ecosystem requires as complete a picture as possible of the ecological structure of the Great Lakes. Therefore, the Commission recommends that:

30. *the Parties encourage the development of information on the cycling of nutrients and energy in the Great Lakes system and ensure that this information reflects the presence of all important trophic levels.*

Risk Assessment

Risk assessment has become an important component of regulatory decision-making but has not been used to assess ecological integrity, which requires the availability of ecosystem damage and risk functions. These are not available for use with existing risk assessment models and methods. Accordingly, the Commission recommends that:

31. *the Parties undertake research to develop and use ecosystem damage and risk functions as a tool in the assessment and management of Great Lakes resources.*

Examples of risk assessments are fish and drinking water advisories, and more recently, a wildlife advisory. With the exception of the impact on human health, none of these advisories relates to ecosystem health or integrity, and relationships between these advisories and the health of the system are not known. Accordingly, the Commission recommends that:

32. *the Parties and jurisdictions undertake specific research to assess whether contaminant levels reflected in advisories are likely to have significant impacts on other components of the Great Lakes ecosystem.*

Specific Objectives

Ecosystem Objectives

Over the years, the Commission has recommended several new or revised specific objectives for incorporation into the Agreement. In the Third Biennial Report, the Commission recommended that the Parties adopt proposed objectives for eleven parameters: asbestos, diazinon, lead, microbiological indicators, mirex, nutrients (phosphorus), pentachlorophenol, polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (dioxins), polynuclear aromatic hydrocarbons (PAHs) and selenium. The Protocol did not incorporate these eleven, but it did adopt two ecosystem objectives, and called for the Parties to consult by July 1, 1988 to consider the adoption of the previously transmitted objectives. It is understood that the Parties are actively considering the eleven objectives, but a final decision as to whether to incorporate those objectives into the Agreement has not been reached.

Prior to adopting the two ecosystem objectives, specific objectives applied to single chemical or physical parameters. In the First and Third Biennial Reports, the Commission encouraged the Parties to consider new kinds of objectives based on such parameters as end use, mass loading, ecosystem indicators and complex mixtures. The Commission supports the new Agreement goal of developing ecosystem objectives for all of the lakes. Objectives for end use, mass loading and complex mixtures can assist the Parties in formulating appropriate ecosystem objectives.

New ecosystem objectives are expressed as population density, either as areal-abundance or catch data, for a fish (the lake trout, *Salvelinus namaycush*) and an invertebrate (the amphipod, *Pontoporeia hoyi*). Both species flourish in cool, low nutrient waters, and their importance in Lake Superior makes them possible indicators of the lake's nutrient status.

Ecosystem objectives have important implications for the way the Commission advises the Parties with respect to meeting the goals of the Agreement. These objectives form a basis to infer the status of many organisms and their relationships which are otherwise unstudied. Correct inferences depend on how data are considered under the objective, relative to how the objective was developed. This means testing the objective and training appropriate users. The Commission welcomes ecosystem objectives in the amended Agreement and recommends that:

33. *the Parties develop agreed upon protocols for measuring the effectiveness of and revising existing and future ecosystem objectives.*

Under the revised Agreement, the Parties have lead responsibility to develop ecosystem objectives. The Commission will review progress and may offer specific proposals. The Commission is aware of several proposals for the use of higher predator species with physiological sensitivities to the many toxic substances documented in the Great Lakes, and which also fill an ecological role often neglected when assessing ecosystem health. The Commission recommends that:

34. *the Parties, in undertaking further work on ecosystem indicators under the Agreement, consider predatory species of birds and mammals as candidates for ecosystem objectives.*

Mass Loading Objectives

A mass loading objective for a substance expresses an allowable rate that can be added to a given system, or its allowable total accumulated mass in a system. Specific objectives state allowable ambient concentrations (mass per unit volume) of various substances in water or biological tissue. Fluctuations in system volume permit different mass loadings for a fixed concentration objective, whereas biological effects may depend on total available mass, rate of change of mass, concentration, or more than one factor. Thus, both mass loading and concentration-based objectives may be needed to address the environmental problems associated with certain chemicals. To some degree this approach is recognized by the revised Agreement.

Annex 3 and its Supplement to the Agreement deal with phosphorus control and illustrate the combination of concentration-based objectives and mass loading objectives. The concentration-based specific objective of 1 mg/l of phosphorus applies to the effluents of major wastewater treatment plants. Mass loading of nutrients limits possible algal biomass, and the Parties have agreed on mass loading limits for phosphorus for each of the lakes to further limit phosphorus inputs.

The Agreement's adoption of a mass balance approach in developing control strategies and relating pollutant loadings to biological effects further supports the notion of mass loading objectives. Extensive data and modeling requirements exist for mass balances; however, the information base suitable to estimate environmental mass balances, and subsequently to develop mass loading objectives, is adequate for only a few chemicals. At a workshop sponsored by the Water Quality Board, Science Advisory Board and the International Air Quality Advisory Board, an estimation of mass balances for several chemical pollutants in the Great Lakes system was attempted. Even for PCBs, a well-studied group of chemicals, the estimation required many assumptions and revealed large uncertainties. The most troublesome assumptions and uncertainties involved processes at the air-water interface (e.g. volatilization, suspension and resuspension, dry deposition) and at the sediment-water interface (e.g. sedimentation and diffusion of particles into and out of interstitial or pore water). The Commission recommends that:

35. *the Parties encourage the development of practical and innovative means of estimating mass loadings of pollutants in sufficient detail to make informed decisions as to the relative significance of the various inputs of contaminants into the Great Lakes system.*

Specific Objectives for Chemical Mixtures

Most chemical discharges, including spills, involve several constituents: fillers, trace contaminants, byproducts, solvents and others. However, most of the knowledge of a pollutant's environmental fate and effects on receiving ecosystems derives from studies of a pure substance. Furthermore, many different compounds, some with extremely long lives, are mixed in given receiving waters. This problem has concerned the Commission for many years, and was a central concern discussed in the 1981 Niagara River Pollution Report. Most testing protocols are for single pollutants and have been well established and standardized. The problem is to predict the effects of mixtures of toxic chemicals from a study of the properties of the individual chemicals comprising the mixture.

Some methods to estimate the toxicological properties of mixtures have been available for many years. Recent work has emphasized providing a firm theoretical foundation to reduce the empiricism of the methods, and standardizing the methods for use in other than research programs. Cost and operational requirements have tended to limit the propensity to test large numbers of combinations, and simple and more economical processes are required. Because very few combinations of chemicals have been shown to have toxicities which cannot be estimated from the toxicological properties of the individual chemicals, the

problem of estimating the toxicities and effects of mixtures and combinations of chemicals is manageable. Therefore, the Commission recommends that:

36. *the Parties, when establishing the toxicological and ecological limits associated with chemicals as single pollutants, also provide information on how these chemicals are likely to behave when mixed with other chemicals, and that the Parties increase research into methods of determining the fate and effects of toxic chemicals in mixtures with a view to developing methods that are simpler, more reliable and more cost effective.*

IV. GREAT LAKES FUTURES

Since the signing of the first Great Lakes Water Quality Agreement in 1972, substantial progress has been made in abating specific pollution problems affecting the Great Lakes. It has been noted in this report, however, that even as progress is being made on pollution cleanup, our understanding of the problem is changing. As we learn more about the presence of contaminants in the environment and their potential consequences, and as we realize that they come from many, often dispersed and unidentified sources, we begin to realize the complexity of the problem. Furthermore, the pollutants we must now confront are difficult to measure and trace, often due to the lack of immediate, obvious symptoms. A number of these toxic pollutants have long-term, subtle and serious consequences. The recognition of the need for an ecosystem approach in the 1978 Agreement, extended and applied to specific programs in the 1987 Protocol, indicates the realization that narrow analyses, without considering their overall context and the variety of linkages within the ecosystem, will no longer be adequate.

The Commission's responsibility to consider systemic effects means it must be concerned with long-term as well as short-term consequences. This realization may lead to quite different perspectives on a problem, and hence to different decisions. As the relationships between local, regional, national and global phenomena become more apparent, and as the cross-system or interdisciplinary linkage of issues between the physical-chemical, biological, economic and social systems become clearer, the wisdom of an ecosystem approach becomes more obvious.

The question of long-term impacts, which tend to characterize the toxic substances problem in particular, highlights the need for approaches to the Agreement that extend beyond the corrective, remedial actions that brought results in the past. Consequently, the Commission has encouraged the adoption of anticipatory and preventive strategies since its Seventh Annual Report under the 1972 Agreement. In response to a 1978 Science Advisory Board workshop, the Commission observed that there is value in shifting emphasis towards the future and away from short-term considerations in order to anticipate and prevent problems rather than simply react to them. The Science Advisory Board also addressed the "anticipate and prevent" theme in its 1987 report, noting its implication for examining socio-economic issues related to the integrity of the Great Lakes Basin Ecosystem. The Board has adopted this approach, consistent with its Terms of Reference within the Agreement that require the development of recommendations "pertinent to the identification, evaluation and resolution of current and anticipated problems."

In its 1985 Report on Great Lakes Diversions and Consumptive Uses, the Commission explicitly went beyond the immediate issues to express concern about how to deal effectively with a non-linear future. That future can be expected to be one that will be impacted by unexpected and unpredictable changes which may have their origin either within or outside the Great Lakes basin. It was further noted that changes from past trends should not only be anticipated by planners, but will require a management approach responsive to a wide range of societal needs and adaptive to unexpected change. These same concerns are as applicable to Agreement-related activities as they are to the water quantity issues addressed in that report.

There are a number of specific future issues requiring anticipatory strategies that the Commission wishes to draw to the attention of Governments, some of which were identified in the 1987 report of the Great Lakes Water Quality Board.

Climate Change

The likelihood of increased long-term temperature levels due to the "greenhouse" effect of elevated carbon dioxide levels in the atmosphere has global consequences, and specific consequences for the Great Lakes basin. It is not too early for Governments to anticipate those potential consequences and develop possible strategies. Greater evaporation rates due to the projected mean annual temperature increases have been predicted to lower lake levels, both by reducing net basin supply and by increasing water withdrawals for consumptive uses, including agricultural irrigation. As the Commission noted in its report on Great Lakes Diversions and Consumptive Uses, these stresses may possibly be exacerbated by increased demand for temperate zone agricultural products due to decreased production in more arid areas as well as increases in other consumptive uses of water in the Great Lakes basin.

With respect to agriculture, increased temperature and reduced soil moisture content may, despite the possibility of moderate overall increases in precipitation, increase the frequency of severe and extended drought periods, and lead to the need for drought-resistant species and crops. The potential for wind and stormwater erosion also increases under such circumstances. At the same time, the existence of lower lake levels could mean that even relatively small pollutant loadings could cause more severe local pollution problems in shallow areas, and the pressure on wetlands as important but threatened components of lake ecosystems would become more severe.

It is likely that the Great Lakes will continue to be an area of relative abundance in water resources, compared to southern and

western North America. There may be additional pressures on the Great Lakes region from increases in population and industrial development, including water-intensive thermal or nuclear electric power production. Such a trend could be even more likely if the population and development shift to the Sunbelt of the recent past should reverse in response to climate change.

Socio-economic consequences in the Great Lakes basin due to climate change may, therefore, lead to resource use conflicts and could further impede Government efforts to achieve the Purpose and Objectives of the Agreement. Resource stewardship practices, such as soil and water conservation and development strategies that are sustainable within the kind of ecosystem envisaged by the Agreement, could become more critical.

In this situation, however, lies also an unusual opportunity. Climate change is one of the few, large-scale environmental changes for which we have some ability and thus responsibility to anticipate, and to formulate adaptive management strategies that can minimize the possible environmental, economic and social discontinuities that might result.

The Chemical Dilemma

Despite warnings about the dangers of toxic chemicals, the number of such chemicals — including many persistent toxic substances — entering the Great Lakes Basin Ecosystem and the uses to which they are put, continue to expand. Often these substances enter the environment in unknown places with unknown or poorly understood impacts, especially with respect to the long term. One such unknown is the cumulative, low-level exposure of biota, including humans, to these substances over many years. The time scale and virtually irreversible nature of the impacts are such that it may be difficult, if not impossible, to correct the problems once they are detected, measured and understood.

The Great Lakes Water Quality Agreement has as a goal the virtual elimination of persistent toxic contamination in the Great Lakes. Yet the nature and extent of problems generated by present methods of producing and disposing of chemical-based products seems antithetical to this goal. Examples of these practices include the production of nondegradable plastics, excessive packaging and pesticides to support monocultural farming activity. Rather than relying on remedial measures, innovative responses should be encouraged to avoid these problems.

As the Commission noted in its Third Biennial Report, the present regulatory system is not well suited to the growing challenge of keeping

up with increasing numbers of potential contaminants and their sources. The Commission continues to support the approach of reducing chemical residuals at the source and, where possible, recycling products containing toxic substances. The recent response of governments to the global ozone problem reflects one dramatic manifestation of the need for preventive strategies in dealing with ubiquitous and persistent toxic contaminants in the biosphere.

A related issue is the escalating amounts of household and industrial solid and liquid wastes beleaguering municipal and environmental authorities throughout the basin. Increasingly, these wastes are composed of nondegradable or environmentally hazardous materials, with very long residual lives. While incineration has become an attractive and seemingly cost-effective alternative for disposing of municipal and industrial solid wastes, there can be dangers associated with large-scale waste incineration due to low-level but continuous emissions of persistent toxic substances. The subsequent, cumulative deposition of these residual contaminants from low temperature incineration could lead indirectly to further degradation of the Great Lakes Basin Ecosystem. This problem further points to the need for reduced waste through source controls, conservation technology and increased consumer sensitivity.

Emerging Technology

Several technological and related developments may offer some relief for the problems posed by pervasive toxic substances. In particular, the Commission notes the role of biological agents in the development of more effective solutions to the generation and disposal of potential pollutants.

Integrated pest management using biological elements to control pests and disease infestations has for some time been used as an alternative to strict reliance on artificial chemical products in agriculture and forestry. The genetic or behavioural modification of pests, or the introduction of enemies of those pests, has allowed the reduction of an otherwise growing dependence on chemical pesticides. It is a technique that holds considerable promise for further research and development with respect to both agricultural and industrial applications.

Biotechnology has been widely recognized, including by the Water Quality Board in its 1987 report, as having the potential for resolving a number of environmental and pollution control problems. Biologically or genetically engineered bacteria, in addition to naturally-occurring organisms, have been the subject of considerable but still nascent attention. The use of bacteria to break down pollutants such as some difficult toxic compounds is a technology for which there is consider-

able experience. As understanding of the natural and genetically modified potential within the field of applied microbiology increases through research and field experimentation, there will doubtless be many opportunities for applications in a variety of manufacturing and agricultural situations. The resultant transformation could, in some cases, turn contaminated waters into environmentally benign and even commercially useful forms. Experiments have shown that microbes can feed on oil and hence can be useful in dealing with oil spills. There is even evidence that they perform better when given nitrogen-based fertilizers to trigger population growth, suggesting possibilities for dealing with oil-based compounds in agricultural and industrial settings. In other studies, pilot scale experiments using biological fermentation to break down organic material contained in pulp mill effluents into economically valuable gasses also hold promise.

Before widespread application, however, considerable research is needed, including careful consideration of some of the dangers inherent in distributing genetically altered material outside controlled situations. There is a need to monitor impacts, and to address the concomitant risk assessment and ethical questions inherent in the human modification of the natural evolution and survival of microbiological and indeed possibly higher order systems.

Economy-Environment Perspectives

The positive links between environmental and economic considerations in decision-making are increasingly being recognized. At the most obvious level, individual pollution control measures often make good economic sense not only for society as a whole but for individual polluters due to improved economic efficiency. One example, borne out in several demonstration projects, is that soil conservation makes good economic sense since it preserves the long and short-term productive capacity of farms and prevents environmental degradation of land and water. There have also been documented instances of industrial cost savings and productivity increases due to the introduction of pollution control technologies involving recycling or more efficient production processes.

The adoption of a perspective that seeks to allow for both reasonable and needed economic development while preserving the integrity of the Great Lakes Basin Ecosystem for the future requires certain premises, each of which have been separately addressed by the Commission on previous occasions. These premises include the shared understanding by various governments and others of the long-term economic and environmental goals to be achieved, the integration of environmental parameters into economic decision-making with an emphasis on both economic and environmental long-term viability, and

a broadening of the commitment to that process to include industry and the public at large.

Indeed, the Great Lakes Water Quality Agreement itself incorporates this critical relationship by specifying that the Water Quality Board should examine programs "in the light of present and future socio-economic imperatives." This aspect of the Board's Terms of Reference has received little explicit attention to date, and the linkage of environmental prerequisites to economic well-being through the protection of beneficial uses has been emphasized in the 1987 Protocol. The Commission believes that if the integrity of the Great Lakes Basin Ecosystem is to be maintained in the face of increasing population, demands for Great Lakes basin water and other resources, and industrial development pressures, present and future socio-economic as well as environmental imperatives must in fact be addressed concurrently and in a systematic way.

A number of intrinsic barriers to progress will have to be addressed in this regard: economic and social disincentives such as institutional and information fragmentation, and the need for more rapid approval and implementation of new technologies including accessible, environmentally-designed resource recovery and disposal facilities. Our society has a highly efficient, incentive-based system for producing and distributing products, but not for recovering and recycling them. Incentives and education directed at the reduction of wastes at all stages of the product life-cycle are needed. In this regard, the Commission has noted some very interesting and promising attempts to recycle various materials and to raise public understanding of the problem at the municipal level in both countries.

The industrial and agricultural sectors in both countries must become engaged in cooperative efforts towards overcoming such barriers and in achieving the common goal of a sustainable economy within the Great Lakes basin. One means of doing that may be to develop mechanisms to bring together industry, governments and other sectors of society to develop a prospectus for the future of the Great Lakes and, more specifically, to develop a Great Lakes Toxics Management Strategy for the future which includes integrative as well as anticipatory and adaptive strategies. Such a concerted approach to dealing with concurrent problems pertinent to the Great Lakes Basin Ecosystem would signal a further positive commitment to ensuring the achievement of the Purpose and Objectives of the Agreement.

Focusing on the Great Lakes

Increasing levels of national awareness and concern for the Great Lakes and for the environment in general has become apparent in both countries. This is a positive sign for the implementation of the provisions of the Agreement. One element in this attitude is the attention given to the work of the Commission, including acceptance of virtually all of the Commission's recommendations pursuant to its review of the Agreement in 1987. The completion of a revised and strengthened Agreement within a very short time frame culminated in the signing of a Protocol at the Commission's biennial meeting in Toledo, Ohio. There have been numerous other contacts and considerable interest expressed in the Commission's activities at the most senior levels of the United States Administration, the Congress, the Government of Canada and the House of Commons, all providing opportunities for an exchange of views and for drawing attention to the issues associated with the Commission's mandate.

Recently, important statements from the highest level within both Governments have indicated the intention of the Parties to give very high priority to environmental policies with direct pertinence to the Great Lakes. The Commission is encouraged by this movement and urges the continued nurturing of this high profile and strong support for the implementation of required measures from the private sector, nongovernmental organizations and the public at large. As stated in the Commission's Second Biennial Report, governmental intervention without public awareness and support makes program implementation difficult if not impossible. Without active community and industrial involvement, it is probably beyond the reach of any agency or government to achieve the objectives of the Agreement.

Signed this 7th day of March 1989 as the International Joint Commission's Fourth Biennial Report Under the 1978 Great Lakes Water Quality Agreement as amended.

Robert C. McEwen
Co-chairman

P.-André Bissonnette
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Commissioner

Donald L. Totten
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Robert S.K. Welch
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APPENDIX A

IJC POLICY STATEMENT ON ITS APPROACH TO THE REVISED AGREEMENT

October 7, 1988

The Protocol amending the Great Lakes Water Quality Agreement, signed in November, 1987, has prompted the International Joint Commission to review its procedures, priorities and work activities, and those of the Agreement institutions. The review was undertaken in the context of the continued evolution of governmental and Commission activities pursuant to their respective responsibilities and functions under the Agreement, and in particular the specific changes in requirements resulting from the recent Protocol.

The Commission has culminated its review by approving an "IJC Policy Statement on Its Approach to the Revised Great Lakes Water Quality Agreement," dated September 14, 1988. A copy of this statement is enclosed for your information. It identifies areas of work that will be subject to continued, increased or reduced effort by the Commission, its Boards and the Regional Office. Overall, an increase in work load is expected. Consequently, requests for additional resources have already been made through the budgetary processes of both countries.

The Commission wishes to encourage governmental attention to the areas of data quality assessment, coordination and the provision to the Commission of data in formats that are readily accessible and suitable to the Commission's analytical requirements. In this regard, the Commission has asked its Great Lakes Water Quality Board to give further consideration to this matter in order to specify more precisely the Commission's data needs.

Text of letters sent to the Right Honourable Joe Clark, Secretary of State for External Affairs of Canada and James Medas, United States Deputy Assistant Secretary of State by the Secretaries of the International Joint Commission.

The Protocol signed on November 18, 1987 amended the 1978 Great Lakes Water Quality Agreement so as to confer new, specific obligations on the International Joint Commission. The overall workload of the Commission will increase substantially in light of its several new responsibilities to review and evaluate programs of the Parties. The Commission expects that the Parties in consultation with the States and Provinces will also assume greater responsibility for some tasks which previously fell to the Commission, due either to the Protocol itself or to the maturation of functions such as data coordination to a degree that the Commission neither needs to nor has sufficient resources to undertake. Consequently, the Commission has assessed its priorities and capacities especially with respect to the work of its Boards and Regional Office, and has agreed on the following statements as to how its resources should be directed.

1. The principal function of the Commission under the Great Lakes Water Quality Agreement is the provision of advice to Governments based largely on technical information and advice from the Great Lakes Water Quality Board and Science Advisory Board whose members serve the Commission in a personal and professional capacity, not as representatives of their agencies or employers. The Commission sees as its primary activities therein, the assessment of the state of the Great Lakes, the assessment of the effectiveness of governmental programs to fulfil the Purpose of the Agreement and, more specifically, the analysis of reports and plans prepared pursuant to the Agreement, as a basis for carrying out the specific responsibilities assigned to it and for formulating recommendations for such new or revised programs and other measures as may be required.

2. While these will be the priorities, the Commission will still consider opportunities to suggest, take, and assist with new initiatives as may be needed from time to time. It is the intention of the Commission that once such initiatives have been sufficiently formulated, they would be recommended for, and then be dependent on, the action of the Governments.

3. Areas to which additional emphasis must be given by the Commission will include:

- assessment of Remedial Action Plans, Lakewide Management Plans and point source impact zone designations submitted or otherwise identified by the jurisdictions;

- assessment of progress in the management of contaminated sediments;
- development of new aspects of surveillance and monitoring including atmospheric deposition, groundwater, the impairment of beneficial uses, human exposure to toxics, and integrated monitoring;
- analysis of reports on a number of the above and other issues, to be submitted by Governments; and
- effective approaches to the identification of research needs, priorities and constraints.

4. Aspects of the Agreement which will continue to receive emphasis by the Commission include:

- the application of ecosystem approaches;
- surveillance and monitoring plans to support comprehensive state of the lakes assessments;
- a coordinated toxic substances strategy (as outlined in the Third Biennial Report), and
- human health dimensions of all programs.

5. Specific areas of reduced effort by the Commission and its boards will include:

- the development of objectives including ecosystem objectives;
- data quality assessment and its coordination, except as required to verify the quality of data used by the boards;
- ongoing coordination of monitoring and surveillance activities;
- adaptation and verification of discharge data from point and nonpoint sources to the extent that they are provided in a more suitable format by jurisdictions.

APPENDIX B

AGREEMENT BOARD REVIEW CRITERIA FOR REMEDIAL ACTION PLANS

Water Quality Board RAP Review Process

The goal of Remedial Action Plans (RAPs) is to define the actions and the timetables to restore all identified beneficial uses in Areas of Concern. Restoration of uses is to be achieved through implementation of programs and measures to control sources and remediate environmental problems. The jurisdictions are responsible for preparation of the RAPs and the International Joint Commission (IJC), in its advisory capacity, will track their development, evaluate their effectiveness to restore beneficial uses, and track implementation. Coordination will be provided by the Water Quality Board. The IJC wishes to ensure that its reviews are impartial, properly focused, and consistent for all RAPs.

The purposes of the three-stage review process is to evaluate each RAP for efficacy to abate sources/inputs, resolve identified pollution problems, and restore beneficial uses. The review should provide constructive criticism and advice. Again, each RAP will be submitted to the IJC for review and comment at three stages and the Water Quality Board's review will be based on the following questions:

Stage 1: Adequacy of problem definition

- Have the environmental problems in the Areas of Concern been adequately described, including identifying beneficial uses impaired, the degree of impairment and the geographic extent of such impairment?

- Has there been identification of specific objectives of the Agreement that are exceeded to the extent that such failure has caused or is likely to cause impairment of beneficial uses, including the area's ability to support aquatic life?

- Have the causes of the use impairment been identified, including a description of all known sources of pollutants involved and an evaluation of other possible sources?

Stage 2: Identification of remedial and regulatory measures

- Are the goals and objectives clear and precise? Are they consistent with the general and specific objectives of the Great Lakes Water Quality Agreement?

- Have remedial measures in place been evaluated?

- Have alternative, additional remedial measures to restore beneficial uses been evaluated?

- Have additional remedial measures to restore beneficial uses been identified, including a schedule for implementation? What beneficial uses (if any) will not be restored? Does the RAP indicate why?

- Have work plans and resource commitments been made?

- Has the surveillance and monitoring program to track effectiveness of remedial actions and confirmation of beneficial uses been adequately described?

- Have the persons or agencies responsible for implementation been identified? Have the beneficiaries or organizations impacted by the RAP been identified? Has there been adequate opportunity for consultation with the public?

Stage 3: Restoration of beneficial uses

- Have all identified remedial measures to restore beneficial uses been implemented according to the schedule in the RAP? If not, why?

- Do surveillance and monitoring data confirm restoration of beneficial uses: If not, why?

In conducting its review, the Water Quality Board reviewers will interact with jurisdictional RAP coordinators to answer questions, clarify concerns and to help ensure consistency. The review coordinator, for each of the three stages, will then prepare a summary report of all the reviews for tabling and discussion by the Water Quality Board's Programs Committee. Collectively, as a review team, it should be possible to undertake a comprehensive review, even though individual reviewers may not have the expertise to address all of the questions. The review coordinator is responsible for ensuring that all questions are answered.

The jurisdiction has the option to revise the RAP, in light of the review comments, before further consideration by the Water Quality Board and the IJC. Once this process has been completed, the review coordinator will present the RAP and the summary report of review comments to the Water Quality Board at the completion of each of the three stages. The Water Quality Board can, at its discretion, transmit the RAP, the summary report of review comments and advice to the International Joint Commission. Alternatively, the Water Quality Board may advise the jurisdiction to review its submission in light of the review comments before the Water Quality Board tenders the RAP, its report and its advice to the IJC.

The Board will report semi-annually on the status of RAP development and implementation to the Commission. All RAPs, review comments and relevant background documentation for each Area of Concern will be maintained in an archive at the Commission's Great Lakes Regional Office.

Science Advisory Board Guidelines for Review of Remedial Action Plans

The Science Advisory Board's review is based on an understanding of the fundamental principle acceded to by the Parties in the Great Lakes Water Quality Agreement and reiterated with special reference to Remedial Action Plans in Annex 2 of the 1987 revision of the Agreement, i.e. "Remedial Actions Plans ... shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Areas of Concern ...." Remedial Action Plans must consider the demographic, economic and institutional context within which remedial decisions are made, the financial and institutional resources that must be mobilized if remedial action is to occur, and the primary economic and institutional impediments to short-term remediation and sustained long-term protection.

a) Does the plan embody an ecosystems approach? Have problems and solutions been examined at various levels of integration?

b) Are human health effects addressed in a comprehensive manner?

c) Have effects been adequately linked to contributing societal causes such as specific private and public sector activities and technological implications?

d) Are the remedial actions adequate to sustain the beneficial uses for the foreseeable future and planning horizon?

e) Does the plan provide for public communication and education? Is there provision for timely involvement of the public in the definition of problems, identification of alternative remedies and implementation of preferred approaches?

f) Does the plan foster innovative approaches to cooperative problem solving by stakeholder groups?

g) Does the plan identify opportunities for the obligation of the private sector to remedy existing problems and prevent future ones? Does the plan identify alternative sanctions and incentives to encourage such private sector activity? Does the plan identify nonenvironmental community objectives that may conflict with attainment of environmental goals identified in the Remedial Action Plans?

h) Do studies necessary to complete the Remedial Action Plans comprise a balanced information system of social, technological and ecological elements?

i) Is there provision for periodic public review and updating of Remedial Action Plans by the jurisdictions?

j) Does the plan identify opportunities for pollution prevention through the application of clean technology, pretreatment, waste reduction, recycling and land management or other measures?

k) Is the report set in an appropriate time frame, e.g. slow processes should be monitored for a long time, as should the consequences of intermittent contamination?

"In the discharge of its responsibilities under this Reference, the Commission may exercise all the powers conferred upon it by the Boundary Waters Treaty ..."

Article VII(2)
1978 Great Lakes
Water Quality Agreement